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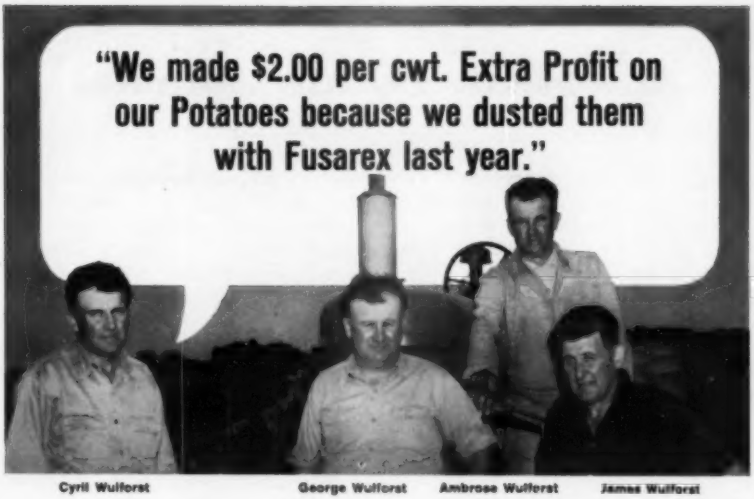

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EFFECTS OF ANTIBIOTIC AND FUNGICIDAL TREATMENTS ON WOUND PERIDERM FORMATION, PLANT EMERGENCE, AND YIELDS PRODUCED BY CUT SEED POTATOES[1]

REINER BONDE AND FAY HYLAND[2]

Studies in Maine have shown that treating freshly cut seed potatoes in a streptomycin or Agri-mycin[3] solution may reduce bacterial seed-piece decay and the blackleg disease (1-4). However, studies also have demonstrated that streptomycin and Agri-mycin treatments, although controlling the decay caused by bacteria, may increase infection of species of *Fusarium* and other fungi (5, 6).

The development of contaminating fungi followed by seed-piece decay may be an important factor in the reduction of normal plant emergence and a satisfactory crop of potatoes. Therefore, a study was conducted to determine the effect of various treatments on the process of wound healing and other phenomena possibly related to seed-piece infection by species of *Fusarium* and other molds.

To determine if a fungicide would decrease the fungous infection in the presence of an antibiotic, captan[4] was added to the Agri-mycin solution. Additional data were recorded to measure the effect of seed-piece treatment on plant emergence and yields produced.

MATERIALS AND METHODS

Healthy 4- to 5-oz. Katahdin seed potatoes were split lengthwise with a sharp kinfe. One of the portions of each tuber was immersed for 5 minutes in a water solution containing Agri-mycin at 100 ppm concentration. The other portion of each tuber was immersed for the same period in distilled water. Both were placed in the same moist chamber at 70° F., conditions considered favorable for rapid suberization and formation of wound periderm.

Sections for microscopic examination were taken from cut surfaces of the apical, middle, and basal ends of each treated and nontreated tuber half. The amount of wound periderm formation was recorded for the same treated and nontreated tubers after intervals of 1, 2, 3, 6, 9, 13, 16, and 20 days after the cut potatoes were placed in moist storage.

The cut sections were fixed in Craf III killing solution, dehydrated by the tertiary butyl alcohol method, and cast in paraffin blocks. The sections were cut with a rotary microtome to a thickness of 18μ, mounted on glass microscope slides, and stained in safranin and fast green in the usual manner.[5]

[1]Accepted for publication February 1, 1960. Project supported with grant-in-aids funds supplied by Eastern States Farmers' Exchange, West Springfield, Mass., and Chas. Pfizer Company, Brooklyn, N. Y.

[2]Plant Pathologist (deceased July 13, 1959), Maine Agricultural Experiment Station, and Professor of Botany, University of Maine, Orono, Maine, respectively.

[3]Manufactured by Chas. Pfizer Company. Contains 15 per cent streptomycin and 1.5 per cent oxytetracycline.

[4]N-trichloromethylmercapto-4-cyclohexane-1:2-dicarboximide. Supplied by California Spray Chemical Corp.

[5]Fast green stains the cellulose walls of storage parenchyma cells green. Safranin stains the lignified and suberized cell walls and the cork layer red.

The mounted sections were examined microscopically, and the treated and nontreated sections from the same tuber were compared for development of suberin, formation of wound periderm, and the effects of treatments on shape and appearance of both the cells of the wound periderm and of the surrounding parenchyma.

In another experiment, Katahdin seed tubers were cut into 1.5-oz. seed pieces on 7 different dates and given different antibiotic and fungicidal treatments before being placed in commercial storage until planted or examined for mold and bacterial infection. The pieces were cut and treated on March 5, 10, 17, and 21 and April 1, 9, and 14 and stored at 39°-41° F. Part of each lot was planted in the field on May 17, and a sample was retained in storage until May 24 when it was examined for surface mold and internal *Fusarium* infection.

The field test included the following treatments: 1) cut, no treatment; 2) treated with captan before cutting; 3) treated with captan after cutting; 4) treated with captan and Agri-mycin before cutting; and 5) treated with captan and Agri-mycin after cutting.

Results

Effect of Agri-mycin Treatment on Suberization and Wound Periderm Formation. Studies on suberization and formation of wound periderm on cut seed potatoes treated with Agri-mycin solution showed that cell divisions were apparent in both the treated and untreated seed tuber halves two days after they had been cut and placed in moist storage (Tables 1, 2). On the third day, one or more new layers of cells had been formed. The number of cells in the wound-periderm layer was less for treated seed pieces than for those untreated for each date the observations were made. Also, it was noted that the wound-periderm layer of the treated potatoes were not continuous and that the cell walls were abnormal in shape and tangentially flattened (Fig. 1). The wound-periderm layer for the untreated potatoes, in contrast, was in most cases continuous. The cells were normal and rectangular in shape and appeared in a regular, even layer.

In addition observations were made to determine whether the Agri-mycin treatment affected the extent of suberization and the depth at which the new layer of wound-periderm cells was initiated. Examination of the prepared sections with the microscope showed that the treatment apparently altered neither the degree of suberization nor the depth at which the wound-periderm layer was formed. The average number of cells outside the wound-periderm layer varied from 2.6 to 3.1 in the treated tuber halves and from 2.2 to 3.3 in untreated tuber halves (Table 2).

Although the cell walls on the cut surfaces of the treated and untreated tuber halves were suberized, it is significant that there was a striking difference in their form and structure. The cell walls in the treated tuber halves were badly crinkled and malformed in contrast to normal cell walls in tuber halves that were not treated.

Effect of Captan and Captan-Agri-mycin Treatments on Surface Mold Growth. The laboratory studies reported here showed that the Agri-mycin treatment affected the wound healing process of cut seed potatoes adversely.

TABLE 1.—*Number and shape of cells in the wound periderm formed on treated and untreated cut potato tubers stored for different periods.*

Days stored at 70°F.	Wound periderm in treated cut tuber[1]			Wound periderm untreated cut tubers[1]		
	No. of cells deep[2]	Extent of layer	Shape of cells	No. of cells deep[2]	Extent of layer	Shape of cells
1	0.0	None	[3]	0.0	None	[3]
2	Few dividing	Cells dividing, no layer	Cells flattened	Few dividing	Cells dividing, no layer	Normal, rectangular
3	1.1	Not continuous	Abnormal, tangentially flattened	1.0	Continuous	Normal, rectangular
6	1.6	Not continuous	Abnormal, tangentially flattened	3.2	Continuous	Normal, rectangular
9	2.9	Not continuous	Abnormal, tangentially flattened	3.2	Continuous	Normal, rectangular
13	2.7	Not continuous	Abnormal, tangentially flattened	3.8	Continuous	Normal, rectangular
16	3.0	Not continuous	Abnormal, tangentially flattened	3.6	Continuous	Normal, rectangular
20	3.2	Not continuous	Abnormal, tangentially flattened	4.1	Continuous	Normal, rectangular

[1]Four- to 5-oz. Katahdin tubers were split lengthwise with a sharp knife. One-half of each tuber was treated by soaking for 5 minutes in Agri-mycin solution (100 ppm), the other half soaked for 5 minutes in distilled water. Both treated and untreated tuber halves were placed in moist chambers at 70° F. until removed for taking samples of cut surfaces for examination.
[2]Average of 5 determinations with aid of the microscope from the apical, middle, and basal part of each tuber half.
[3]No wound periderm cells formed, parenchyma cells normal and not malformed.

Also, since previous observations indicated that cut potatoes treated with the antibiotic were more susceptible to fungous infection than similar cut potatoes that were not treated, an effort was made to determine if fungus infection and seed-piece injury could be reduced or eliminated by combining the fungicide captan with Agri-mycin in the treating solution.

In this experiment Katahdin tubers were cut to 1.5-oz. seed pieces on 7 dates, from March 5 until April 14. They were subjected to the previously mentioned fungicidal and antibiotic-fungicidal treatment and placed in commercial bin storage until planted on May 17 or examined for fungus infection on May 24.

Growth of *Penicillium spp.* and other molds on the cut surface of the potato seed pieces examined May 24 was practically absent on the seed pieces that received no treatment and also on the seed pieces that were treated with captan in the absence of Agri-mycin (Table 3).

The data show that the addition of Agri-mycin to the captan treating solution greatly favored the growth of fungi on cut surfaces of potato

TABLE 2.—*Suberin formation and shape of cell walls outside of wound periderm layer of treated (Agri-mycin) and untreated cut potato tubers.*

Days stored at 70°F.	Treated with Agri-mycin[1]			Not treated with Agri-mycin [1]		
	No of cells outside wound periderm[2]	Cell walls suberized	Cell walls crinkled	No. of cells outside wound periderm[2]	Cell walls suberized	Cell walls crinkled
3	2.6	All	Outer	2.2	Outer	None
6	2.9	All	All	2.9	All	None
9	3.0	All	All	2.9	All	None
13	2.6	All	All	3.0	All	None
16	2.9	All	All	3.0	All	None
20	3.1	All	All	3.3	All	None
LSD 0.5	N.S.			N.S.		

[1]Treated 5 minutes in solution containing 100 ppm Agri-mycin in distilled water. Control from same tuber soaked for 5 minutes in distilled water.
[2]Average of 5 determinations made with aid of microscope from apical, middle, and basal portion of each treated and untreated tuber half.

seed pieces (Fig. 2). The prevalence of mold infection was increased as the length of time the cut and treated potatoes were stored before being examined was increased. Infection was present whether the potatoes were cut before or after being treated. Seed potatoes treated before cutting tended to have less infection than did those treated after cutting. This was most apparent when the seed potatoes were cut late in the season and were in storage for short periods of time before being examined.

Effect of Captan and Captan-Agri-mycin Treatments on Fusarium Decay. The effects of the treatments on the development of decay by *Fusarium spp.* on cut seed potatoes is shown in Table 4. Decay was relatively unimportant in 1958 and was present only in 1 to 6 per cent of the control seed pieces that were cut and stored on the different dates.

Treating with captan either before or after cutting completely eliminated decay by *Fusarium spp.* on seed pieces cut on the 3 later dates, namely, April 1, 9, and 14. On the other hand, the addition of Agri-mycin to the captan treating solution greatly increased the incidence of infection by *Fusarium spp.* Seed-piece decay for the captan-Agri-mycin treatment before cutting varied from 5 to 40 per cent and from 0 to 38 per cent when the treatment was done after the seed was cut. The addition of Agri-mycin decreased the effectiveness of captan for the control of potato seed-piece decay.

Effect of Captan and Captan-Agri-mycin Seed-Piece Treatments on Plant Emergence. Data on stand or plant emergence for the treated seed potatoes, when planted in the field at Aroostook Farm in 1958, show that the percentage of seed pieces that sprouted and produced plants was not reduced significantly by the fungous infection (Table 5). Furthermore, the treatments did not affect the general appearance of the growing plants.

Growth of *Penicillium spp.* was superficial and penetrated only the outside cells of the cut surfaces of the seed pieces but did affect their

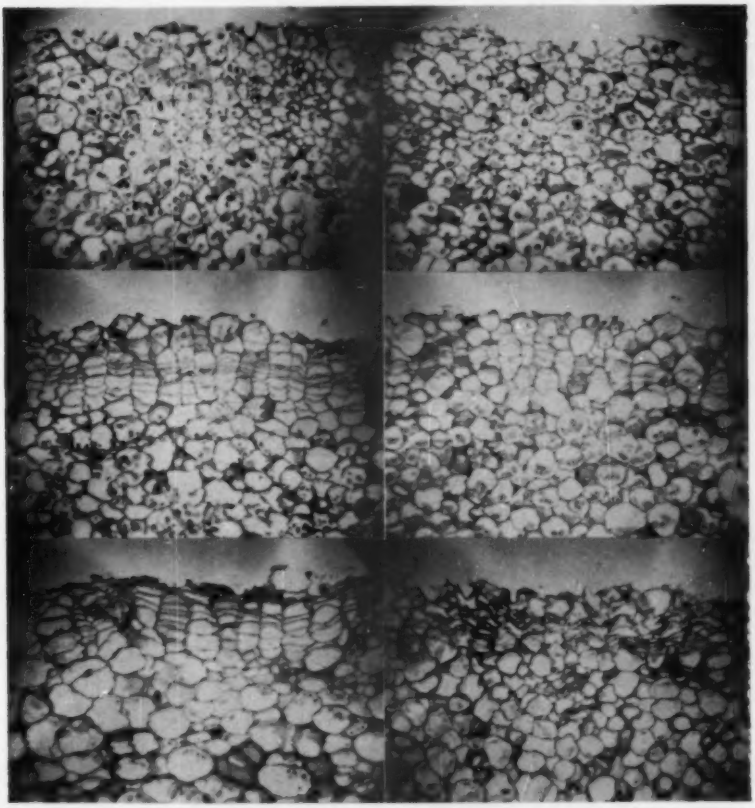

FIG. 1.—Comparison of wound periderm and shape of cells in cut surface layer of untreated and treated Katahdin seed pieces. Examined at different intervals after being cut.

Top.—Left, control, dipped in water; right, treated in Agri-mycin solution; both 1 day after being cut.

Middle.—Left, control dipped in water; right, treated in Agri-mycin solution; both 9 days after being cut.

Bottom.—Left, control dipped in water; right, treated in Agri-mycin solution; both 20 days after being cut.

Note the irregular layer of periderm and distorted cells in the treated seed pieces.

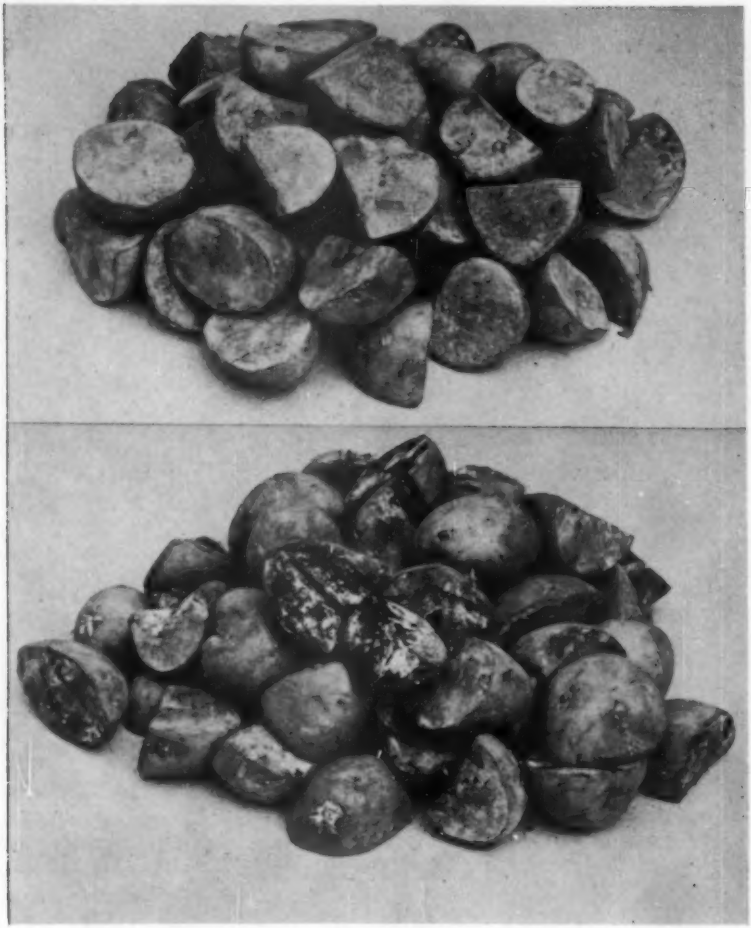

FIG. 2.—*Top*—treated with captan solution in the absence of Agri-mycin.

Bottom—treated in solution containing captan (4 pounds in 100 gallons) plus Agri-mycin concentration, 100 ppm. Both placed in commercial storage for 40 days before being examined and photographed.

TABLE 3.—*Penicillium growth on potato seed pieces that were cut, then treated with captan or captan plus Agri-mycin, and stored for different periods.*[1]

Treatment	Percentage of seed pieces with Penicillium growth on cut surfaces after being in storage from date indicated to May 24[2]						
	Mar. 5	Mar. 10	Mar. 17	Mar. 21	Apr. 1	Apr. 9	Apr. 14
No treatment	0.0	0.0	0.0	0.0	1.0	1.0	0.0
Captan before cutting[3]	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Captan after cutting[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Captan and Agri-mycin before cutting[3]	79.0	90.0	70.0	100.0	30.0	20.0	20.0
Captan and Agri-mycin after cutting[3]	100.0	70.0	50.0	50.0	70.0	58.0	58.0

[1]Katahdin seed-potatoes were cut and treated on the indicated dates and placed into trackside storage maintained at 38-41° F. until examined May 24, 1958.
[2]Based on one sample of 100 seed pieces from each treatment and cutting date.
[3]Freshly cut seed potatoes were dipped in a water suspension of captan at the rate of 2 lb in 100 gal of water or in a treating solution containing captan, 2 lb in 100 gal of water and "Agri-mycin 100" at 100 ppm.

TABLE 4.—*Fusarium decay in potato seed pieces that were cut, then treated with captan or captan plus Agri-mycin, and stored for different periods*[1]

Treatment	Percentage of seed pieces with *Fusarium* decay on cut surfaces after storage from date indicated to May 24[2]						
	Mar. 5	Mar. 10	Mar. 17	Mar. 21	Apr. 1	Apr. 9	Apr. 14
No treatment	4.0	2.0	5.0	4.0	6.0	2.0	1.0
Captan before cutting[3]	4.0	0.0	1.0	3.0	0.0	0.0	0.0
Captan after cutting[3]	2.0	4.0	3.0	0.0	0.0	0.0	0.0
Captan and Agri-mycin before cutting[3]	26.0	8.0	26.0	40.0	15.0	25.0	5.0
Captan and Agri-mycin after cutting[3]	38.0	21.0	9.0	7.0	15.0	11.0	0.0

[1]Katahdin seed potatoes were cut and treated on the indicated dates and placed into track-side storage maintained at 38-41° F. until examined on May 24, 1958.
[2]Based on one sample of 100 seed pieces from each treatment and cutting date.
[3]Freshly cut seed pieces were dipped in a water suspension of captan at the rate of 2 lb in 100 gal of water or in a treating solution containing captan, 2 lb in 100 gal of water containing "Agri-mycin 100" at 100 ppm.

TABLE 5.—*Percentage of plant emergence from Katahdin seed potatoes which were cut, treated, and stored for different periods.*[1]

Treatment	Percentage emergence of seed stored from date indicated until planted[2]							
	Mar. 5	Mar. 10	Mar. 17	Mar. 21	Apr. 1	Apr. 9	Apr. 14	Av.
No treatment	100.0	97.6	98.4	96.8	97.6	100.0	100.0	98.6
Captan before cutting[3]	100.0	98.4	99.2	98.4	99.2	100.0	100.0	99.3
Captan after cutting[3]	99.2	96.8	98.4	97.6	100.0	99.2	100.0	98.7
Captan and Agri-mycin before cutting[4]	96.0	97.6	98.4	90.4	98.4	98.4	99.2	96.9
Captan and Agri-mycin after cutting[4]	99.2	97.6	97.6	97.6	100.0	99.2	100.0	98.7
Freshly cut—control[5]	100.0	100.0	98.4	100.0	100.0	100.0	100.0	99.8
Mean	99.1	98.0	98.4	96.8	99.2	99.5	99.9	98.6
LSD .05	N.S.	N.S.	N.S.	4.77	N.S.	N.S.	N.S.	N.S.

[1]Based on a total of 125 seed pieces in 5 replicated plots for each treatment and date of cutting.
[2]Each lot was stored at 38-41° F. from the indicated date until planting on May 17, 1958.
[3]Freshly cut seed pieces dipped in water suspension of captan at the rate of 2 lb in 100 gal of water.
[4]Freshly cut seed pieces dipped in water suspension of captan at 2 lb in 100 gal plus "Agri-mycin 100" at 100 ppm.
[5]Representative samples of uncut potatoes stored with the cut potatoes on the dates indicated.

general appearance. This may be an important factor for the sale and acceptability of cut seed potatoes by buyers.

Likewise, decay of seed pieces caused by *Fusarium spp.* did not reduce the percentage of seed pieces that sprouted and produced normal plants.

Effect of Captan and Captan-Agri-mycin Treatments on Yield. Freshly cut seed potatoes (cut and planted May 17) produced higher yields than did the seed potatoes cut earlier in the season, namely, on March 5, 10, 17 and 21 (Table 6). The freshly cut seed potatoes, however, did not produce higher yields than the seed cut at the later dates, namely, April 1, 9 and 14. Therefore, the data show there was a tendency for seed potatoes cut and stored before planting to yield progressively less than freshly cut seed potatoes as the interval of time between cutting and planting date was increased. It should be recalled that the extent of seed-piece rot by *Fusarium spp.* and other fungi also was increased when the seed was cut for a long period of time in advance of planting (Table 4).

There was evidence that *Fusarium* seed-piece decay was a factor in reducing the yields of seed that was cut, then treated with captan plus Agri-mycin, and stored from March 17 to May 24. Seed-piece decay in

TABLE 6.—*Yields produced by seed pieces which were cut before or after treatment, or untreated and stored for various intervals before planting*[1]

Treatment	Yield (cwt. per acre) for seed cut on date indicated[2]							
	Mar. 5	Mar. 10	Mar. 17	Mar. 21	Apr. 1	Apr. 9	Apr. 14	Av.
No treatment	387.5	399.7	398.5	358.5	377.6	356.7	356.1	376.4
Captan before cutting	391.1	389.9	395.4	370.2	392.4	386.8	372.7	385.6
Captan after cutting	396.7	407.7	396.0	400.3	379.4	375.1	386.2	391.8
Captan and Agri-mycin before cutting	388.0	383.1	384.4	365.9	377.0	386.2	375.1	380.1
Captan and Agri-mycin after cutting	378.8	407.1	373.3	389.9	391.8	412.0	369.6	388.7
Freshly cut—control[3]	402.8	426.2	412.7	414.5	368.4	379.4	359.1	394.8
Average	390.5	402.2	393.6	383.1	381.3	382.5	369.6	386.23
LSD .05	N.S.	27.43	38.81	N.S.	N.S.	33.94	N.S.	N.S.
.01		37.75	52.88			46.31		

[1] All planted May 17, 1958.
[2] Average of 5 replicated 1-row plots each planted with 25 seed pieces.
[3] Representative samples of uncut potatoes stored with the cut potatoes on the dates indicated.

these experiments, however, did not result in significant reductions in emergence. The yields, therefore, were not reduced significantly for the experiment taken as a whole.

DISCUSSION AND CONCLUSION

A microscopic study of periderm formation on cut surfaces of potato tubers subsequent to treatment with Agri-mycin failed to offer a conclusive explanation as to why more mold occurred on treated than on untreated pieces. Even though the cells of the periderm layer of the treated pieces were abnormal in shape and the periderm layer itself was thin in certain areas and somewhat discontinuous in others, only a few fungal hyphae were found penetrating it. However, mold did not develop extensively in the seed pieces used for microscopic study because of the short period of time between cutting the tubers and the time when tissue samples were taken for study.

Although Agri-mycin and Agri-mycin plus captan treated seed pieces were definitely more subject to molds, the moldy pieces produced stands and yields comparable to those from clean seed pieces, under the conditions of the experiment. However, it is possible that the emergence and size of yield produced might be reduced significantly if infected seed pieces were planted under soil and climatic conditions more favorable for rapid fungus and bacterial decay. For example, other experiments conducted in Maine have shown that seed pieces infected with rot-causing organisms may decay rapidly and fail to produce normal plants in poorly drained

soil or when the moisture content and temperature are relatively high (unpublished data).

The fact that Agri-mycin treatment increased surface mold growth and infection by *Fusarium spp.* is important in the production and sale of cut seed potatoes in Maine. The development of mold growth on the cut potatoes will detract from their general appearance on the market and thus reduce buyer acceptance.

Summary

Treatment of freshly cut seed potatoes in a 100 ppm Agri-mycin solution reduced the amount of bacterial seed-piece decay but it also reduced the rate and extent to which the wound protective layer was formed. The treatment caused abnormality in the shape of the cells of the newly formed periderm layer and the adjacent parenchyma tissue. Combining the fungicide captan with Agri-mycin in the treating solution did not eliminate the effect of the antibiotic on the formation of a wound-periderm layer in cut seed potatoes. The Agri-mycin-captan treatment increased the susceptibility of the seed pieces to surface growth by molds and to decay by *Fusarium spp.* The antibiotic-fungicidal treatment, however, did not reduce plant emergence or size of crop produced in the experiments conducted in Maine in 1958.

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GENETIC VARIATION AMONG HAPLOIDS OF THE COMMON POTATO

S. J. PELOQUIN AND R. W. HOUGAS[1]

INTRODUCTION

A considerable degree of genetic variability may be expected among haploids (2n=24) of the common potato, *Solanum tuberosum* L. (2n=48). This reasoning is based upon the knowledge that [1] commercial varieties of *S. tuberosum*, as well as breeding selections of this species, are highly heterozygous (9, 10, 11); [2] reduction in ploidy results in an increased potential for expression of variability; and [3] haploidy provides a rapid means of inbreeding (5).

Genetic variability found among the 28 'raw" or "primary" potato haploids previously reported (4, 6) plus one additional haploid of Katahdin will be described in this paper. Genetic variability of "secondary" haploids, 2n=24 progeny resulting from inter-mating the "primary" haploids, will be reported at a subsequent date.

DESCRIPTION OF *Solanum tuberosum* HAPLOIDS

Twenty-two of the 29 haploid plants were derived, following interspecific matings, from the commercial variety Katahdin. Where possible, and unless otherwise indicated, comparisons made in this paper will either be between the haploids of Katahdin or between these 22 haploids and the parent Katahdin. The parentage of all haploids is listed in Table 1. Comparisons of vigor, plant size and tuber yield are based upon 1959 field trials at Sturgeon Bay, Wisconsin. Since the quantities of planting stock were very limited, no statistical treatment of these data has been attempted .

Plant Size and Vigor

The ranges of variability for plant vigor and size are striking (Fig. 1). A few plants, such as US-W5 and US-W8, are small and weak. The majority of the haploid selections have fair to good vigor and the mature plants are approximately ½ to ⅔ the size of the parent (Fig. 3). A few haploids, particularly US-W20 and US-W23, have very good vigor and equal or exceed the parent in size.

Leaves

The inter-haploid variability for leaf size and shape is considerable. Leaves of the haploids are, with two exceptions (US-W7 and US-W20), noticeably narrower and smaller than those of the parent Katahdin (Fig. 2). The leaves of the haploids are generally lighter green than those of the parent and in three instances, US-W5, US-W8 and US-W26, are somewhat chlorotic.

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Cooperation of the Inter-Regional Potato Introduction Project (IR-1) in providing *Solanum* material is hereby acknowledged.

TABLE 1.—*Ovule fertility of Solanum tuberosum haploids.*

Haploid	Parent	Haploid ♀ X *S. phureja* (P.I. 195198) ♂			
		Flowers pollinated	Fruit	Seeds	Seeds/Fruit
US-W1	Katahdin	7	4	826	208
US-W2	Minn. 44-2	15	8	21	3
US-W3	Minn. 15-2-10-1-2	45	38	2136	56
US-W4	Minn. 20-20-34	12	10	896	90
US-W5	Minn. 113-1	6	5	699	140
US-W6	Minn. 20-20-34	2	2	282	141
US-W7	Katahdin	23	16	745	47
US-W8	Katahdin	No flowers	..	..	..
US-W9	Katahdin	No flowers	..	..	..
US-W10	Katahdin	5	3	124	41
US-W11	Katahdin	9*	4	199	50
US-W12	Katahdin	8	6	260	43
US-W13	Katahdin	10	2	76	38
US-W14	Katahdin	19	9	493	55
US-W15	Katahdin	6	1	31	31
US-W16	Katahdin	No flowers	..	..	..
US-W17	Minn. 10-5-12	3*	2	10	5
US-W18	Katahdin	No flowers	..	..	..
US-W19 (lost)	ND 457-1	..	..	..	..
US-W20	Katahdin	7*	4	215	54
US-W21	Katahdin	10	3	102	34
US-W22	Katahdin	5	0	0	0
US-W23	Katahdin	2	2	217	109
US-W24	Katahdin	23	4	77	19
US-W25	Katahdin	10	6	253	59
US-W26	Katahdin	No flowers	..	..	..
US-W27	Katahdin	11	10	530	53
US-W28	Katahdin	18	1	36	36
US-W29	Katahdin	16	14	1737	124

*Flowers were pollinated with a different selection of *S. phureja*.

Flowers

All 6 of the haploids from the Minnesota breeding stocks and 17 of the 22 Katahdin haploids have flowered to date. Most of the haploids flower less and for a shorter period than Katahdin. Two haploids, however, US-W29 from Katahdin and US-W3 from Minn. 15-2-10-1-2, flower heavily for 3 weeks or more of the summer growing season. Under the short-day conditions of fall, winter and early spring, most of the haploids tuberize very rapidly and fail to flower. As in the parents, flowering may be induced in many selections during this period by lengthening the photoperiod with artificial light. Of the Katahdin haploids, 9 have white flowers and the remainder are pigmented ranging in color from light to dark pink.

Fertility

Twenty-two of the 23 haploids that have flowered have been used successfully as female parents (Fig. 5). Two haploids, US-W1 from Katahdin and US-W4 from Minn. 20-20-34, are functional as both male and female parents in inter-haploid matings as well as in matings with

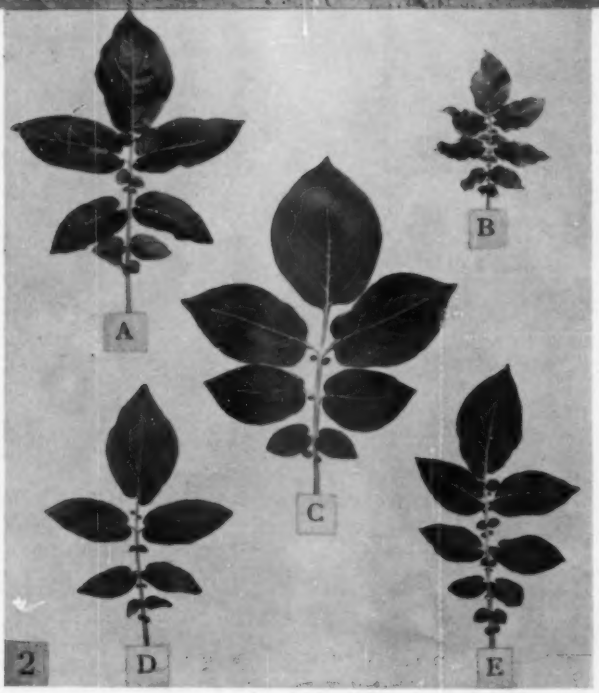

FIG. 1.—*S. tuberosum* haploids: Left to right—US-W5, US-W6 and US-W7.

FIG. 2.—Leaves from the variety Katahdin and from its haploid offspring: A) US-W7; B) US-W13; C) Katahdin; D) US-W1; E) US-W9.

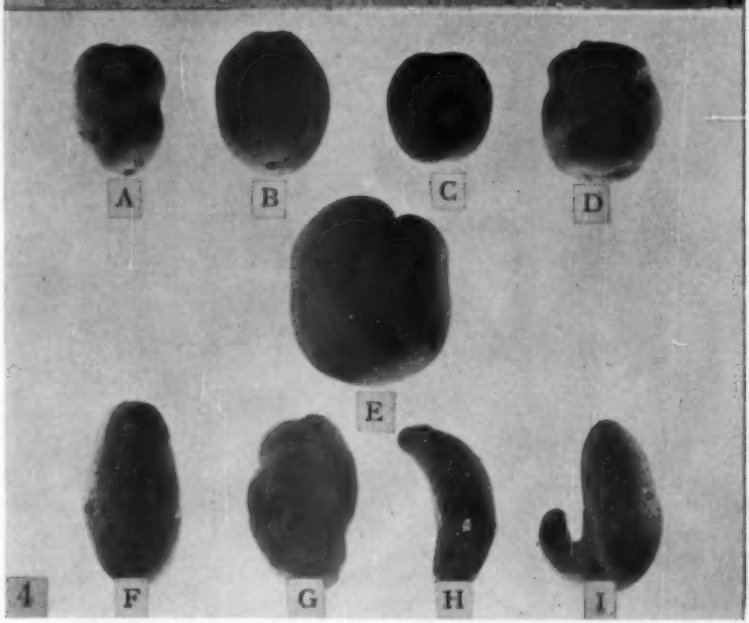

FIG. 3.—*S. tuberosum* and haploids: Left to right—variety Merrimack, US-W1 and US-W2.

FIG. 4.—Tubers from the variety Katahdin and from its haploid offspring: A) US-W1; B) US-W12; C) US-W15; D) US-W23; E) Katahdin; F) US-W22; G) US-W20; H) US-W24; I) US-W28.

certain haploids (2n=24) *Solanum* species. Pollen stainability of the haploids ranged from 0-20 per cent for the male-sterile individuals and from 60-80 per cent for the male-fertile individuals. The variation in pollen stainability among the haploids is illustrated in Figs. 6-9.

The criterion employed for judging the female fertility of the haploids is the production of viable seed following matings with the cultivated South American species *Solanum phureja* (2n=24). Data concerning the ovule fertility of the haploids are summarized in Table 1. Inter-haploid matings have not been used as a measure of fertility because [1] there is evidence of genetic incompatibility in some of the haploid-haploid matings and [2] as previously noted, most of the haploids which have flowered to date do not normally have sufficient stainable pollen for male fertility.

A study of meiosis and crossability in haploids US-W1 and US-W3 was previously reported (12).

Tubers

The inter-haploid variability for number, shape, size and yield of tubers is very marked. The range of shapes among the Katahdin haploids include round-oval (US-W12, US-W15, US-W23), long-rough (US-W20), long-smooth (US-W22), pear-shape (US-W1) and hook-neck squash (US-W24, US-W28). The shape of Katahdin is superior to that of the majority of its haploid offspring (Fig. 4). The number of tubers per hill ranged from 6 (US-W13, US-W18) to 33 (US-W23) with most haploids having 10-15. A light russeting of the tubers occurred on one haploid of Katahdin (US-W15).

Tuber size and yield of the haploids are usually considerably smaller than the parent. However, two haploids, US-W20 and US-W23, produced in 110 days individual hill yields of 3¼-4 and 3½-3¾ pounds, respectively, as compared with 4½-5 pounds of the parent Katahdin. In a later harvest (124-day growing season) the haploid US-W20 produced an individual hill yield of 7 pounds as compared with 5¾ pounds of the parent. One haploid from Katahdin, US-W29, had not set tubers at the time of harvest, but it does set tubers in the greenhouse under short-day conditions.

Discussion

Changes in the ploidy of plants usually results in an increase or decrease in vigor and size. Induced tetraploids, for example, are generally larger in one or more plant parts than their diploid parents (2, 13, 14). Higher levels of ploidy, on the other hand, may result in loss of vigor and dwarfness. Johnstone (7) reported this in induced octaploids (2n=96) of common potato varieties (2n=48). The total yield of tubers, as well as the tuber size, of these octaploid potatoes was reduced.

Reductions in ploidy arising from reduced parthenogenesis also result in loss of vigor and size in the haploid offspring of most plant species (8). This is the case with all but one of the 22 haploid plants derived from the potato variety Katahdin. The one exception, US-W20, equalled the parent in vigor and exceeded it in tuber yield in a 124-day growing season.

The loss of vigor and size, which usually characterizes reduction in ploidy, is but a partial measure of the total genetic consequence of

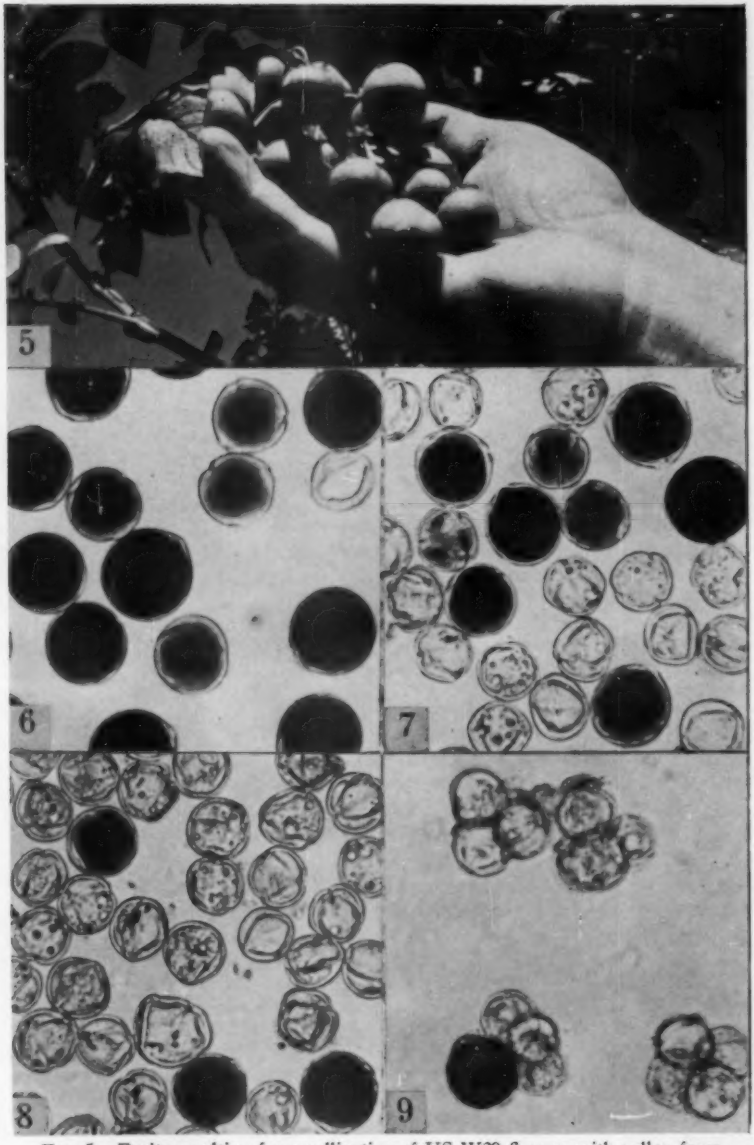

FIG. 5.—Fruits resulting from pollination of US-W29 flowers with pollen from *S. phureja*.

FIG. 6-9.—Pollen of *S. tuberosum* haploids stained with aceto-carmine: 6) US-W1; 7) US-W29; 8) US-W14; 9) US-W20.

haploidy. Haploidy also allows for increased potential in the expression of genetic variability. The specific amount of variability expressed among the haploids derived from a particular parent is dependent upon the genetic nature, especially the heterozygosity and ploidy, of the parent. Obviously, much greater variability would be expected among the haploids from a heterozygous parent than from one which is relatively homozygous. The level of ploidy as well as the nature of the ploidy of a parent will also influence the variability expressed among its haploid offspring. A difference would be expected, for example, in the degree of variability among the haploids, *i.e.* monoploids, from a diploid parent and among the haploids, *i.e.* diploids, from its induced autotetraploid. This difference may be attributed in part to the differential in inbreeding due to haploidy. About seven generations of selfing a diploid are required to approximate the amount of inbreeding obtained through the extraction of haploids, *i.e.* monopolids, from such a diploid parent. Three generations of selfing an autotetraploid are required to approximate the degree of inbreeding obtained through the extraction of haploids, *i.e.* diploids, from such an autotetraploid parent. It should be further noted that each haploid derived from a diploid carries but one genome and consequently is completely homozygous. By contrast each haploid derived from an autotetraploid carries two genomes and as a result the occurrence of a completely homozygous haploid, *i.e.* diploid, considering the probable magnitude of heterozygosity in most autotetraploids, would be a very rare event. These latter relationships may be illustrated by considering the frequency of homozygous individuals expected among the haploids derived from a diploid of the genotype AaBb, in other words, the frequency of homozygous gametes expected from such a genotype, as compared with the expected frequency of homozygous haploids (calculated from the expected gametic frequency) from the induced autotetraploid, AAaaBBbb. The calculation of the gametic frequency of the autotetraploid assumes random chromosome segregation.

Parental Genotype	*Expected Gametic Frequency*
Diploid—AaBb	1/4AB :1/4Ab :1/4aB :1/4ab
Induced Autotetraploid—AAaaBBbb	1/36AABB :1/36AAbb :4/36AABb :4/36AaBB :16/36AaBb :4/36Aabb :4/36aaBb :1/36aaBB :1/36aabb

From a comparison of these gametic frequencies it may be seen that in the diploid parent with the genotype AaBb four classes of haploids each with the same expected frequency and each completely homozygous will occur. In the case of the autotetraploid parent nine classes of haploids will occur, only four of which are completely homozygous. The expected frequency of these four homozygous classes combined is only 1/9 (1/36AABB + 1/36AAbb + 1/36aaBB + 1/36aabb).

The genetic nature of *S. tuberosum* must be borne in mind in considering the effects of haploidy in the potato. First, this species is considered an autotetraploid by most investigators (1, 3, 9, 11). Second,

most selections of the common potato, especially the commercial varieties, are highly heterozygous (10, 11). Hence considerable variability would be expected among the haploid offspring of potato due to the close inbreeding of a highly heterozygous parent. This expectation has been realized in the variability expressed among the 22 "raw" haploids of the variety Katahdin.

It should be re-emphasized, however, that due to autotetraploidy only a portion of the inherent variability of the potato will be expressed in populations of its "raw" haploid offspring. This aspect will be dealt with in greater detail in a subsequent paper, however, one simple example will be drawn to illustrate this point.

Make the following assumptions: [1] the autotetraploid parent carries genes in the triplex condition (AAAa), [2] dominance is complete at both the diploid and the tetraploid level, [3] the inheritance pattern of the gene in question is conditioned by random chromosome segregation; then the "raw" haploids extracted from such triplex genotypes will be of two genotypes, AA and Aa. Hence, the genetic variability due to the action of the recessive gene "a" would not be expressed among the "raw" haploids. Such variability would be expressed, however, among selfed and sib-mated populations of the "raw" haploids or among monoploids from such "raw" haploids.

Summary

1. Genetic variability among 29 haploids (2n=24) of the common potato (2n=48) is described.

2. Plant parts of the haploids are reduced in size, with few exceptions, as compared with those of the parent.

3. The tuber yields of the haploid plants are in general, considerably less than those of their parents. One notable exception, however, is the haploid US-W20, which in an initial limited trial outyielded its parent Katahdin in a 124-day growing season.

4. Twenty-two of the 23 haploids that flowered are functional as female parents. Two haploids, US-W1 from Katahdin and US-W4 from Minn. 20-20-34, are functional both as male and female parents in inter-haploid matings as well as in matings with *Solanum phureja* (2n=24).

5. Certain genetic consequences of haploidy are discussed.

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SPINDLING SPROUT OF POTATO TUBERS ASSOCIATED WITH A STRAIN OF CALIFORNIA ASTER YELLOWS VIRUS[1]

L. F. LIPPERT[2]

Spindling sprout, a condition in potato tubers (*Solanum tuberosum* L.) characterized by very weak, thread-like sprouts initiating from eyes of apparently sound tubers, has been observed in limited amount in California during the past 15 years. The disorder is world-wide in occurrence, being termed hair sprout, thready eye, filosite and Fadenkeimigkeit. The tuber abnormality has been attributed to such causes as unfavorable environment during growth or storage (2, 20), potato viruses (5, 8, 10, 11, 15, 22), the fungus *Colletotrichum atramentarium* (Beck. & Br.) Taub, (21) and the potato psyllid insect (*Paratrioza cockerelli* Sulc.) (9, 19).

The aster yellows virus causing potato "purple top wilt" has received considerable study in the United States. Long (7) was the first to link spindling sprout and aster yellows virus, although the virus in certain areas of this country does not cause the abnormal sprout condition (6, 12).

In California, Snyder *et al.* (19) were not able to show that spindling sprouts were incited by a virus; however, they did produce abnormal sprouts by exposing potato plants to colonies of potato psyllids. Raymer (13), in Oregon, observed a spindling-sprout condition associated with late breaking virus infections. This virus was considered to be identical with an isolate of western aster yellows from California.

This study was undertaken to evaluate the role of aster yellows in the spindling sprout condition in California, and to develop a method of field production of tubers predisposed to spindling sprouts.

MATERIALS AND METHODS

Strain of the virus.—The Tulelake strain of aster yellows[3] was recovered initially from a single potato plant exhibiting typical aster yellows symptoms in Tulelake, California. Infected potato scions were grafted to tomato and the virus isolated from tomato using non-viruliferous aster leafhoppers (*Macrosteles fascifrons* Stal.). Identification of the virus as a strain of California aster yellows was based on successful inoculations and symptom development on various plants, and by cross protection studies with other aster yellows strains (4).

Insect inoculations and field grafting studies.—Field studies were conducted to evaluate the relationship of Tulelake strain of aster yellows virus in the potato plant and spindling sprout of the tuber. Plants of Russet Burbank and White Rose varieties were exposed to viruliferous aster leafhoppers in the greenhouse and transplanted to the field. Severe symptoms developed rapidly on these plants causing death before any tubers were set.

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[3]Virus was isolated, identified and cultures supplied by Dr. J. H. Freitag, Department of Entomology, University of California, Berkeley, Calif.

In order to retain this source of inoculum, leaf buds from symptomatic plants were grafted into 54 healthy 45-day old plants in the field (early graft series). Both cleft and bud grafts were made, with ⅜ inch wide strips of parafilm plastic used to bind the graft union. Two Russet Burbank plants from this first graft series developed symptoms within 20 days after grafting. These 2 plants provided virus-infected scions for grafting an additional 20 healthy plants of each variety (late graft series). Stock plants for this late graft series were 65 days from planting.

Tomato (*Lycopersicon esculentum* L.) and *Nicotiana rustica* L. had proven valuable as scion sources for graft inoculations of aster yellows to potato in greenhouse studies. To evaluate these plants in the field, scions from symptomatic greenhouse-grown tomato and *N. rustica* plants and field-grown potatoes were grafted to healthy potato plants. Ten scions from each source were grafted to 50-day old stock plants of both varieties.

The effect of time of plant infection and resultant spindling-sprout development in the tubers was studied by cleft-grafting groups of 10 White Rose and Russet Burbank plants with scions from aster yellows infected *N. rustica*. Five groups of plants were grafted at 14-day intervals, 30, 44, 58, 72 and 86 days after planting.

Symptom development and plant condition were recorded for each grafted plant during the season. Tubers from individual plants were harvested and bagged separately 120 days after planting, and placed in storage to sprout. Tubers from non-grafted plants were harvested as controls.

Results

Symptoms of Tulelake strain of aster yellows on potato.—Symptoms of aster yellows on potato were similar in the two varieties tested. However, symptoms differed under greenhouse or field conditions and with insect or graft inoculations. In the greenhouse, virus symptoms appeared on potato approximately 30 days after insect inoculations. Plants were stunted and young leaves were narrow, curled upward and chlorotic, with frequent purple pigmentation on the leaflets at point of petiole attachment. After the onset of symptoms, new growth was restricted to leaf axils in the form of aerial tubers (Fig. 1A) or occasionally as aerial stolons (Fig. 1B). Greenhouse symptoms produced by graft inoculations with scions from potato, tomato, and *N. rustica* did not include aerial stolons, although all other symptoms were evident. Early death of infected plants was common with aster yellows infections in the greenhouse.

Potato aster yellows symptoms on field plants induced by insect inoculation were identical to symptoms of insect inoculations in the greenhouse except that leafy shoots developed at leaf axils without aerial tuber or stolon development. Also, purple pigmentation was generally lacking, so that pigmentation was not reliable as a diagnostic symptom in the field. Early symptoms were followed rapidly by severe wilting, and within 2-3 weeks infected plants were dead. Aster yellows symptoms developed on 41 of 50 insect-inoculated White Rose plants and 24 of 50 Russet Burbank plants. The aster yellows virus was verified as the cause of these symptoms by successful graft transmission to and symptom development on *N. rustica* tester plants in the greenhouse.

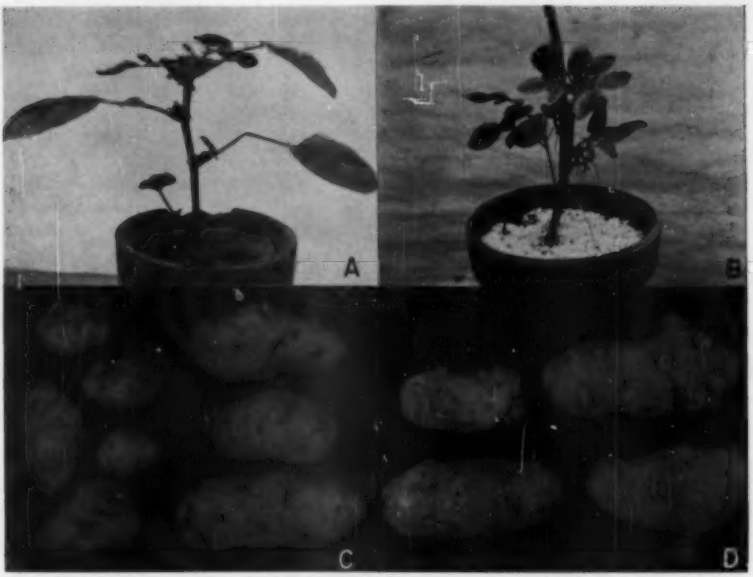

FIG. 1.—Symptoms and spindling-sprouted tubers produced on potato plants infected with Tulelake strain of aster yellows virus. (A) Insect-inoculated White Rose plant exhibiting stunting and aerial tuber development and (B) with aerial stolons and leafy terminal swellings. (C) Spindling- and normal-sprouted tubers from graft-inoculated White Rose plants and (D) spindling-sprouted tubers from Russet Burbank plant.

Symptoms appeared on the grafted stem of field plants of both varieties approximately 21 days after grafting, and in some cases appeared later on non-grafted stems of the plant. Absence of aerial tubers and lack of consistent purple pigmentation were the main differences in graft-induced symptoms between greenhouse and field locations. Russet Burbank plants produced more distinctive symptoms than did plants of the White Rose variety. In addition to those plants with definite symptoms, some of the grafted plants showed only wilting and early death of the grafted stem with the remainder of the plant apparently healthy. The balance of the plants appeared healthy with no visible virus symptoms.

Cleft grafts were made from all grafted potato plants onto healthy *N. rustica* in the greenhouse. However, none of these tester plants produced aster yellows symptoms, so that diagnosis of infections in grafted potato plants relied entirely on field symptoms

Spindling sprout of the tuber.—Sprouting characteristics of tubers from grafted plants proved spindling sprout to be an expression of Tulelake aster yellows virus in potato. Sixteen of 54 plants in the early graft series produced one or more tubers with spindling sprouts while tubers from 7 of 40 plants in the late graft series were abnormal. No tubers from non-grafted control plants produced spindling sprouts.

There appeared to be no correlation between symptoms on the plant and spindling-sprout development in the tubers; abnormal tubers formed on plants which remained symptomless throughout the season as well as on symptomatic plants. Several plants diagnosed as infected with aster yellows failed to produce spindling-sprouted tubers. (Table 1). This discrepancy cannot be explained entirely by invalid symptom diagnosis, for only one of the 2 symptomatic Russet Burbank plants used as scion sources for the late graft series produced spindling-sprouted tubers. Also, from the data in Table 1, it is not possible to correlate early death of the plant in the field with either aster yellows infections or with spindling-sprout production. Symptomatic plants in the greenhouse produced tubers with normal sprouts except for one of the White Rose variety. Plants grown from spindling-sprouted tubers planted in the greenhouse, aside from being spindling and weak, did not exhibit any symptoms which would indicate carry-over of aster yellows or other potato viruses.

Only rarely did every tuber from a plant sprout abnormally. Most plants produced 40-60% spindling-sprouted tubers, with various plants ranging from 8-70% abnormal tubers. The severity of infections and symptoms did not increase the percentage of tubers with abnormal sprouts.

Tubers producing spindling sprouts were not distinguishable from normal tubers by external or internal appearance. Abnormal tubers could be identified only by their characteristic elongated and weak sprouts after germination. (Fig. 1-C,D).

TABLE 1.—*Symptom expression and spindling-sprout production on potato plants grafted with aster yellows-infected potato scions.*

Variety	Plant group	Number of plants in each symptom class[1]			Total number of plants	Spindling-sprouted to total tubers[2]	
		+	—	O		Number	Per cent
Russet Burbank	All plants	17 (9)[3]	31 (6)	13 (4)	61	..	..
	Plants with spindle-sprouted tubers	8 (5)	9 (3)	2 (2)	19	74/166	44.6
White Rose	All plants	8 (5)	27 (8)	18 (13)	53	..	..
	Plants with spindle-sprouted tubers	2 (1)	9 (5)	8 (8)	19	76/158	48.1

[1]Description of symptom classes: (+) definitely aster yellows, (—) wilting and/or death of grafted stem above the scion with remainder of plant apparently healthy, (O) apparently healthy.

[2]Tuber numbers and percentages obtained from only those plants producing one or more spindling-sprouted tuber.

[3]Numbers in parentheses refer to plants dead at harvest, 120 days after planting.

Virus scion source.—Aster yellows symptoms were produced in only 2 of 20 potato plants grafted with potato scions, one plant from each variety. However, 15 of the 20 plants died prematurely. The condition

of wilt and death of grafted stem was apparent on potato plants grafted with tomato and *N. rustica* scions, but no definite aster yellows symptoms were produced.

Spindling-sprouted tubers were produced by 7 Russet Burbank and 8 White Rose plants grafted with potato scions and by a single Russet Burbank plant grafted with *N. rustica* scions.

Time of infection.—The time of infection study was designed to develop the optimum period in growth of potato plants at which spindling sprouts could be produced by graft inoculations. Test graft of potato scions to healthy *N. rustica* verified the presence of virus in only one of 10 White Rose plants from the 30 day grafting date. Unmistakable symptoms of aster yellows developed, however, in 4 Russet Burbank plants from this same grafting date.

Spindling-sprouted tubers were produced by 1 to 4 of the 10 Russet Burbank plants from each of the grafting dates, totaling 13 of 50 plants with tuber symptoms. Only 5 White Rose plants, 3 from the 30-day and 1 each from the 58- and 72-day graft dates produced spindling-sprouted tubers. Weights and numbers of tubers indicated that infections initiated 30 days from planting resulted in tubers reduced in size and number, but nearly 100% subject to spindling sprout. Infections initiated 44 or more days after planting produced tubers of normal number, but slightly reduced in size, of which approximately 50% sprouted abnormally.

Early sprouting of spindling-sprouted tubers.—A comparison of the sprouting rate of spindling- and normal-sprouted tubers was possible from the sprouting records of tubers in the aster yellows virus studies. Sprout readings were taken 7, 12 and 21 weeks after harvest. All tubers from field graft studies were classified in storage as either normal-, spindling- or non-sprouted. The final number of tubers was 126 spindling-sprouted and 858 normal for the White Rose variety and 101 spindling-sprouted and 958 normal for the Russet Burbank variety. The rates of sprouting of spindling-sprouted and normal tubers (Fig. 2) support earlier observations that tubers predisposed to spindling sprouts tend to sprout earlier than normal tubers.

Discussion

The Tulelake strain of aster yellows virus used in these studies had not been previously investigated in potato with respect to symptom development and association with tuber spindling sprout. Symptoms of this virus in potato are very comparable to symptoms of California or western aster yellows described by Severin (17) and Raymer (13). Aerial stolons observed in greenhouse insect inoculations have been reported for the California strain (13, 17), but not for eastern strains of the virus. Purple pigmentation of the foliage was a consistent feature of the disease in the greenhouse, but not in the field. Therefore, the terminology "purple-top wilt disease" as ascribed to potato aster yellows infections from other areas may not be applicable to field infections in California.

The percentage of potato plants infected with the virus by leafhopper inoculation (82% for White Rose and 48% for Russet Burbank) was as great or greater than infections reported by other investigators. Younkin

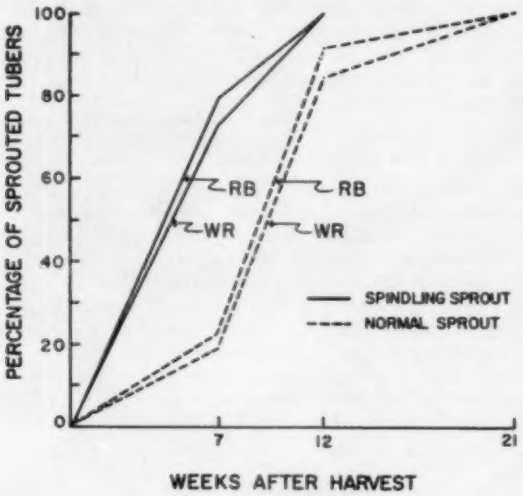

FIG. 2.—Comparison of sprouting rate of normal and spindling-sprouted tubers of the White Rose (WR) and Russet Burbank (RB) varieties.

(23) reported a maximum of 40.8% infections with the eastern strain and Severin and Haasis (18) reported 50% infections with the western strain. The development of symptoms on 25 of 114 plants grafted with virus infected potato scions is comparable to symptom development on 7 of 30 plants grafted by Epps (3) with the eastern strain and on 59 of 132 plants by Self and Darling (16) with the western strain.

Spindling-sprouted tubers produced from graft inoculations of the Tulelake aster yellows virus were in every way comparable to spindling-sprouted tubers collected in storage, for which no history of the parent plant was available. Small diameter and rapid growth of sprouts, early sprouting of the tuber and lack of a tuber borne incitant were features in common. The wilted or flaccid condition and internal necrosis often reported for spindling-sprouted tubers (1, 14) were not observed in these studies.

The production of spindling-sprouted tubers by graft inoculations of aster yellows virus to potato offers a practical method for producing abnormal tubers under controlled field conditions. The following procedure is recommended for spindling-sprout production after evaluating such factors as scion source, time of infection, and percentages of spindling-sprouted tubers produced by the plants:

1. Use aster yellows-infected potato scions, obtained from initially insect-inoculated plants, as the source of virus. Single leaf buds are suitable for scions and make good union with the potato stock.

2. Stock plants should be at least 45 days old, from date of planting, to insure maximum size and number of spindling-sprouted tubers. The

45-day age coincided with flowering of the potato plants in these studies and flowering has been correlated with initiation of tuber formation.

3. Graft each stem of the stock plants to insure infection of the entire plant and thereby increase numbers of spindling-sprouted tubers from the plants.

Summary

The Tulelake strain of California aster yellows was associated with a spindling-sprout condition of potato tubers in California. Grafting of virus infected potato scions to healthy potato plants in the field resulted in tubers with spindling sprouts, whereas non-grafted control plants produced only normally-sprouted tubers. Plants grafted as early as 30 days and as late as 86 days after planting produced spindling-sprouted tubers. No correlation existed between plant symptoms or early death of plants and spindling-sprout development in the tubers. Aster yellows infected tomato and *Nicotiana rustica* scions were ineffective in producing abnormal tubers when grafted onto potato plants. Tubers predisposed to spindling sprouts germinated earlier than normal tubers.

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BOOK REVIEW

BIOMETRICAL GENETICS: Proceedings of an International Symposium held at Ottawa, August 1958, sponsored by the Biometrics Society and the International Union of Biological Sciences. Oscar Kempthorne, ed., New York: Pergamon Press, 1960, 234 pp., $8.50.

The proceedings of the international symposium involved 19 papers presented by 29 of the worlds leading scientists in the fields of Biometrics and Genetics. The book is in three parts as follows: Theoretical Genetics, 9 papers; Design of Experiments, 5 papers; and Experimental Results, 5 articles. The compilation will be most useful to Biometrical Geneticists. For many plant and animal breeders, however, there will be barriers to understanding parts of the book. The articles are rather technical and presupposes a sound training in statistics.

Orientation of the book is to situations in which loci are not identifiable, for example, it indicates that certain phenotypic attributes may be the result of various, different genotypes. Professor Kempthorne also stresses the importance of attributes being affected by environment.

In conclusion, one can only compliment the editor, authors, Pergamon Press, and Unesco which aided in the publication. This is a significant contribution to scientific literature.

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NEWS AND REVIEWS

A POTATO BREEDING TECHNIQUE USED FOR TEXAS[1]

BRUCE A. PERRY, ROBERT V. AKELEY, AND W. B. COOK[2]

In the National Potato Breeding Program conducted at Plant Industry Station, Beltsville, Maryland, the usual schedule is to: 1) Plant selected parents in the greenhouse in January; 2) make the desirable pollinations from March to April; 3) harvest the seed from the seedballs in May and June; 4) plant the seed in 3-inch pots in August and September; and 5) harvest the new seedling tubers in November and December.

Ordinarily the small seedling tubers from this first generation are stored 3 to 4 months at Beltsville and then divided and sent to Maine and other cooperating States for increase. Selection of the second-generation clones are grown later in northern production areas.

Single-tuber seedlings are spaced 34 inches apart, both within and between rows, to avoid mixtures and to produce maximum yields. Wide tuber spacing permits the use of mechanical equipment, which helps keep down operating expenses, in harvesting .

At harvest second-generation tubers are selected first on the basis of horticultural characters and are stored for several months. In the spring each seedling clone is subdivided into lots for 10-hill increase plots and for various disease resistance tests.

A different procedure was used for the cooperating program with the Texas Experiment Station during the last 3 years. In this program the first-generation seedlings, after harvesting in December at Beltsville, are sent directly to the Winter Garden Experiment Station. Near the end of January these seedling tubers are treated with potassium thiocyanate, 1½ per cent solution for 1½ hours, and planted immediately in the field at wider than normal spacing, 24 or more inches, between seed-pieces. Some of the family lines with large populations are subdivided and planted in more than one area within the State.

The seedlings are harvested and the selections are made in May. The selections are made on the basis of desirable horticultural characters and in some areas on the basis of resistance to scab and heat and wind damage. Sufficient tubers of each selection are then sent to the Maine Experiment Station for increase in 20-hill plots. The tubers are treated with potassium thiocyanate and planted by the middle of June. Normal cultural and roguing practices are carried on throughout the growing season. The increase by mid-September, when the third-generation tubers are harvested, varies from 15 to 20 pounds per 20-hill row. This increase provides enough seed for a 40-hill row increase in Maine the following year and for evaluating the clones in 5-hill plots in 5 locations in Texas the following January.

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[1]Accepted for publication June 20, 1960.

[2]Superintendent, Winter Garden Substation of the Texas Agricultural Experiment Station, Crystal City, Texas; Principal Horticulturist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Md.; and Agriculturist, Missouri Pacific Lines, Houston, Texas, respectively.

All seedlings do not respond the same to the dormancy-breaking treatment. In 1959, 235 seedlings were selected at harvest and sent to Maine for increase. Only two of the seedlings failed to germinate and only 22 had less than 50 per cent germination.

The advantages of growing the first-generation seedling tubers in Texas are: 1) saving of a year in general increase; 2) making the first selections under environmental conditions where the seedlings eventually will be grown; and 3) selecting for scab and heat and wind resistance. Moreover, the quick increase in Maine produces sufficient material for State-wide tests in Texas the following season. This speeding of the increase and testing program should shorten the time needed to obtain superior varieties for production in Texas.

IMPROVED POTATO GRANULES

An improved method of manufacturing potato granules — used in making some instant mashed potatoes — has been successfully laboratory tested by USDA scientists at the Western utilization division in Albany, Calif.

The time-consuming addition of already dried granules to cooked potatoes in the initial drying stage has been eliminated. ARS food technologists found that this "add-back" is not essential to high quality.

New techniques reported to industry include cooking at low temperature (185° to 190° F.), conditioning sliced potatoes before cooking by soaking in water at low temperature, and partial drying and granulation in new-type equipment. Peeling, slicing, and final drying remain unchanged.

Slow cooking apparently tends to produce in potato starch an open structure that is maintained through processing. This open structure also increases the moisture absorbing capacity of the final product. Slow cooking and conditioning before cooking improve texture when granules are reconstituted.

Properly conditioned cooked potatoes can enter the drying system directly, making add-back unnecessary.

In the new granulating-drying equipment, rotating blades gently disintegrate the cooked potatoes on a moving belt or in a trough as a warm air current removes moisture. The blades have a mild compressing and shearing action essential to drying.

A drum-dryer reduces moisture to 55%. After conditioning at room temperature or lower, the granulator dryer reduces moisture to 35%. Final drying is done in a fluidized-bed dryer.

—Reprinted from AGRICULTURAL RESEARCH, *Aug., 1960*

ERRATUM

Pages 233 and 234, Volume 37, No. 7.

Correction: Figures 1 and 2: The description of each figure is correct; the graphs *only* are reversed.

CHIP COLOR TESTER

Medicine and potato processing now have something in common. The same device that doctors use to test for diabetes also indicates whether potatoes will turn into golden yellow or dark brown chips, says Prof. Ora Smith of the New York State College of Agriculture.

The Cornell specialist recently discovered that this device, long used by doctors, can also be used by potato chip chefs in the home, restaurant, or processing plant. The Chip Color Tester is distributed by the Potato Chip Institute International.

Smith explained that darkening of potato chips in cooking is caused by the presence of sugar in potatoes. "The chip tester measures the presence of sugar almost instantly," he said.

The vegetable crops expert described the chip tester as a yellow paper ribbon covered with a chemical that reacts only with sugar. The ribbon is applied flat to one half of a cut potato.

When sugar is present, the ribbon will turn shades of green. The darker the green, the more sugar the potato contains and the darker the chips it will make. If the ribbon remains yellow, no sugar is present and the potatoes will make perfect golden colored chips.

"This is the first chip color test that can be done in just a few seconds," Smith reported. Previously, potato processors had to use lengthy chemical tests to predetermine the color of chips and other potato products fried in deep fat.

A test such as this is essenital for potato chips which are acceptable only when they fry to light golden colors, the specialist commented. While French fries and other deep fried potato products are acceptable at darker shades, the chip tester can also be used on them to predetermine their final colors. He said homemakers can use the tester for small batches; restaurants can use it, as potato processors do, for large batches.

There is no need to discard a lot of potatoes if the tester registers a dark green shade, Smith pointed out. The potatoes can be "reconditioned" for processing into perfect yellow chips or French fries.

Smith explained that storing potatoes at temperatures between 65 and 75 degrees F. will lower the sugar content enough after a period of three weeks so that the potatoes will be ready for deep frying.

For longer periods of time, he recommended storing the potatoes at 50 degrees F. and using a sprout inhibitor. When the potatoes come out of storage, the chip tester will indicate little need for further reconditioning because the potatoes will make yellow chips or French fries as they are, Smith said.

USDA IMPROVES SAMPLING PLAN FOR INSPECTION OF POTATOES AT SHIPPING POINT

The U. S. Department of Agriculture announced adoption of an improved "sampling" plan for inspection of potatoes at shipping points. The revision makes inspection of potatoes more accurate, USDA said, and therefore of greater value to users of the inspection service.

Under the new plan, the minimum sample for each lot inspected is increased by one container whenever an inspected container is found to exceed any of the tolerances allowed in the U. S. standards for grades.

Here is an example: In making his inspection of a load of potatoes, packed in 100 lb. bags, the inspector selects — at a minimum — a sample of eight containers. (This number would be higher, perhaps 30, for consumer-sized packages.) As he proceeds with his inspection, he finds that one of the containers has defects exceeding the grade tolerances — it may, for example, have 2% decay, or 7% external defects.

When he finds one package that exceeds the permitted tolerance, he increases the sample by one package so that the minimum sample automatically becomes nine containers. For each additional package found to exceed the permitted tolerance, he increases the size of the sample by one more package. If two containers are found with defects exceeding the tolerance, for example, the minimum sample is increased to 10 containers; if three are found, it goes to 11; and so on.

In all cases, the starting point is the usual minimum sample, as specified in each State, for the size of container and the number of containers in the load being inspected. The new procedure still gives the inspector full authority to increase the number of containers selected for a sample whenever he deems that desirable.

The new sampling plan was developed in the Fruit and Vegetable Division of USDA's Agricultural Marketing Service after careful statistical analysis of the degree of error that occurs in selecting a sample to be representative of an entire load. AMS statisticians were able to plot a graph of the relationship between the number of containers selected as a sample and the number of "bad" (defects exceeding the permitted tolerance) containers in the lot. Applying this statistical analysis, the "one-for-one" method was worked out as a means of greatly increasing the accuracy of the sample's representation of the lot. And, since the grade of the sample is projected to the entire load, this increase will consequently increase the accuracy of grade of the entire shipment.

The new procedure will help to prevent packers from easing off on quality toward the end of a load, after the inspector has found most of the samples — the first five or six, for example, out of a required eight — to be well within grade tolerances. It will also improve accuracy of the inspection of consumer-sized packages, where representativeness of the sample is especially important because of the limited number of potatoes contained in each package.

The new sample procedure is being applied this season only to inspection of potatoes at shipping point. After this test of its use in actual inspection work, it will be modified if found desirable, or expanded to apply to potato inspections at all levels. Based on this experience, AMS officials said, further expansion may then be made to other commodities.

CHEMICAL TO STOP SPROUTING OF STORED POTATOES TESTED BY USDA

By use of a chemical commonly known as CIPC, potatoes can be stored at 55° F. for as much as a year without sprouting, the U. S. Department of Agriculture reported recently. This use of the chemical has been accepted for registration by the USDA.

A tolerance for the chemical [isopropyl N (3-chlorophenyl) carbamate] to cover residues left by its commercial use was established recently by the Food and Drug Administration.

Paul C. Marth, of USDA's Agricultural Research Service, Beltsville, Md., discovered the potential of CIPC as a sprout inhibitor for potatoes in making tests of the effects of the compound on different plants. Dr. Marth, and Peter H. Heinze, of the Agricultural Marketing Service, tested the chemical on several varieties of potatoes. Sprouting lowers potato quality, shortens storage life, and causes shriveling because moisture is lost through sprouts.

When properly used, CIPC prevents deterioration of potato appearance and does not affect the taste, the investigations showed. Potatoes do not make good chips if they are stored at temperatures below 50 degrees F. Such temperatures are maintained in potato warehouses to check sprouting of untreated potatoes, but these temperatures are not effective after potatoes have been stored three to four months. At temperatures under 50 degrees the starch in the potatoes changes to sugar, and chips made from potatoes so stored turn dark brown when processed.

Harvested potatoes may be treated at low cost by dipping, or by aerosol or other means of spraying, with an 0.25 to 0.5 percent CIPC solution.

CIPC is also used as a herbicide to control annual grasses in cropland. It is used in research on ornamental plants for disbudding lilies to produce stronger bulbs. The formulations used for these purposes must not be used to treat potatoes, scientists emphasize, because they may contain other chemicals that give off-flavors, and for which tolerances have not been established.

INHERITANCE OF IMMUNITY TO VIRUS S IN POTATOES (ABSTRACT)[1]

R. H. BAGNALL AND D. A. YOUNG

Potato seedlings of different crosses were tested for resistance to potato virus S. Preliminary sap-inoculation, followed by serological testing and attempts to recover the virus on *Nicotiana debneyi* Domin. screened out the most susceptible seedlings. The survivors were grafted with infective scions of Seedling 41956 and retested for presence of virus S. Some seedlings not infected by sap inoculation, were infected by grafting, as were the "resistant" varieties Sebago and Alpha. Seedlings free from virus S after both inoculations, and presumably having resistance equivalent to that of the "immune" variety Saco were:
Saco x Self: 29/39 (74%); Saco x Wis. X 143.52: 20/148 (14%); Sdlg. 41956 x Sdlg. 96-56 (parents of Saco): 4/52 (8%); Saco x Sdlg. 96-56: 4/53 (8%); Saco x Katahdin: 1/26 (4%); Katahdin x Self 0/20; Sdlg. 96-56 x Self: 0/37. The "immunity" appears to be controlled by more than one gene, and one, at least, seems to be recessive. "Immunity" to virus S and "immunity" to virus X segregated independently in the Saco x Wis. X 143.52 and 41956 x Sdlg. 96-56 crosses.

[1]Accepted for publication September 19, 1960.
Contribution No. 41, Research Station, Canada Department of Agriculture, Fredericton, New Brunswick.
Can. Dept. Agric. Research Sta. Ann. Project Rept., Feb. 15, 1960.

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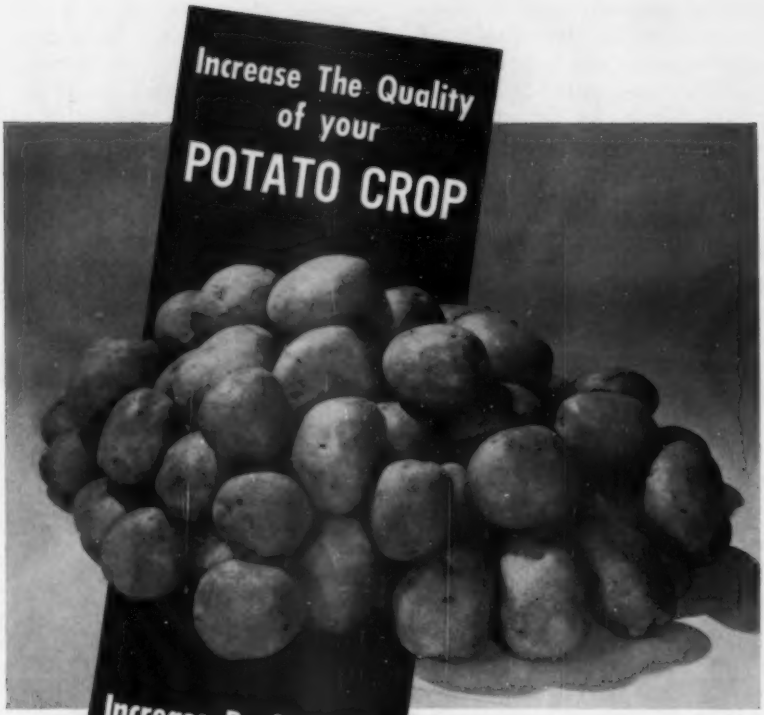

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